Atmospheric radiative heating under different cloud types observed by CERES

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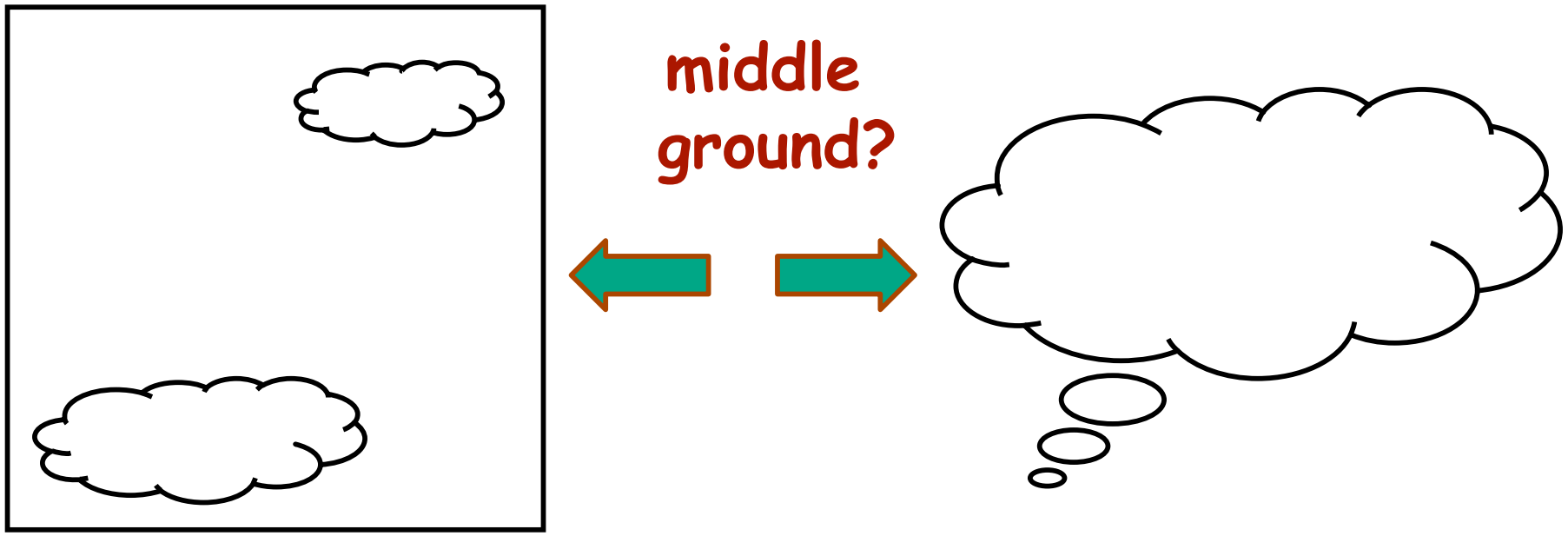
gridded data & individual cloud systems



easy for GCM to use
but mix different types

physical properties
but scale differences
with GCMs

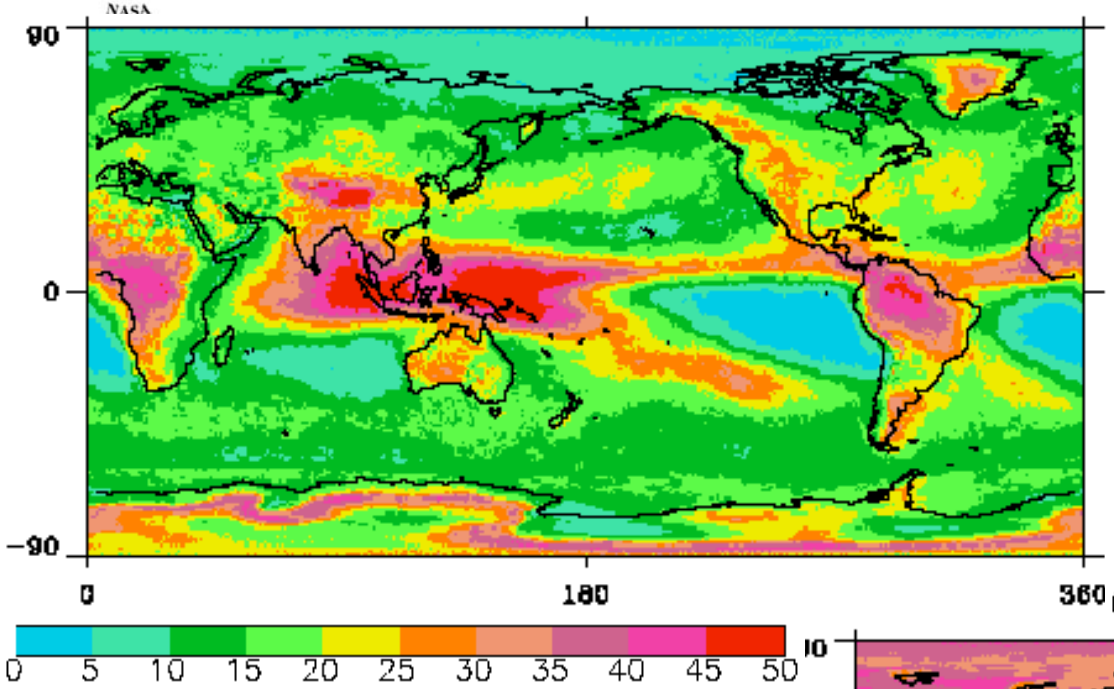
Introduction

- last CERES STM: cloud types
  identification
  water path distribution
  time series of TOA & surface radiation

- Additional issues about high and low cloud studies:
  storms: precipitation on selected high cloud areas
  atmospheric radiative characteristics
  environmental conditions -- on-going study

- Applications for models:
  probability distribution, variability, parameterization

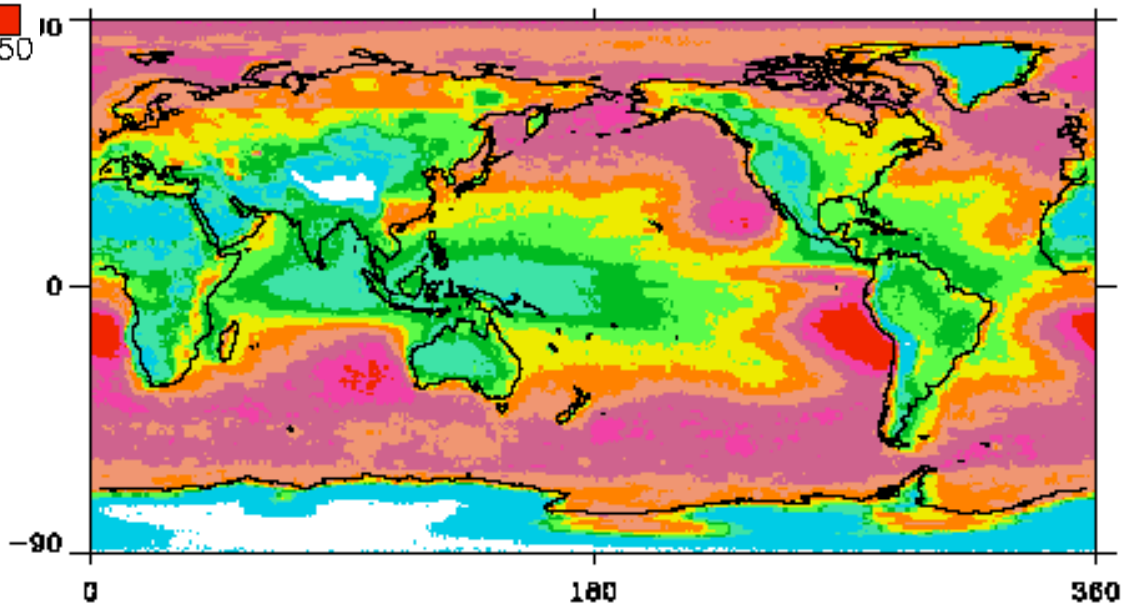
Global distribution (2005)



high clouds
Pc < 440mb

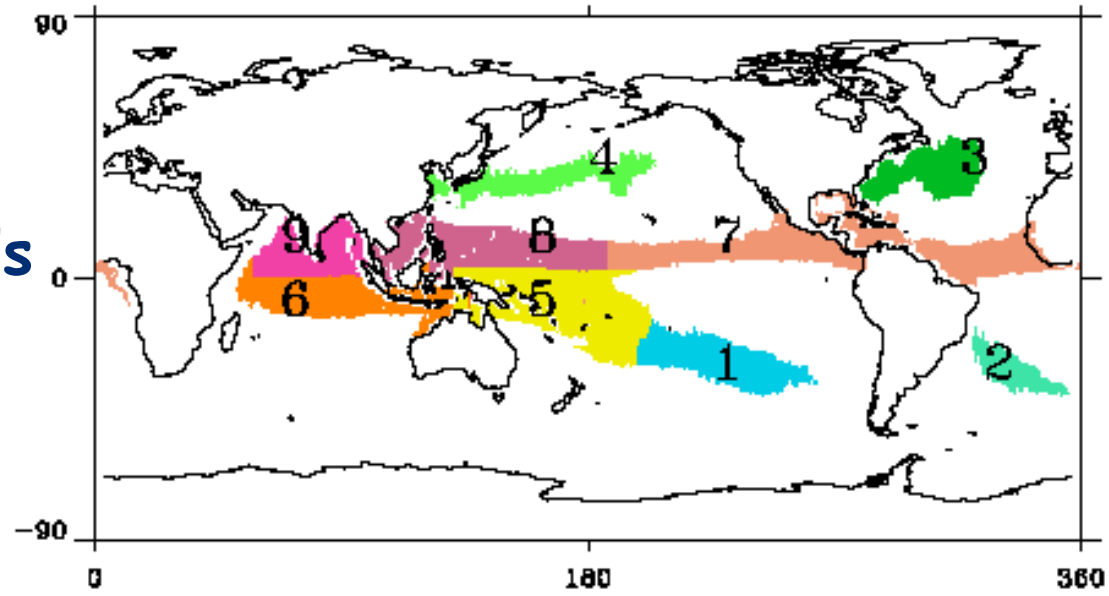
from Aqua

low clouds
Pc > 680mb

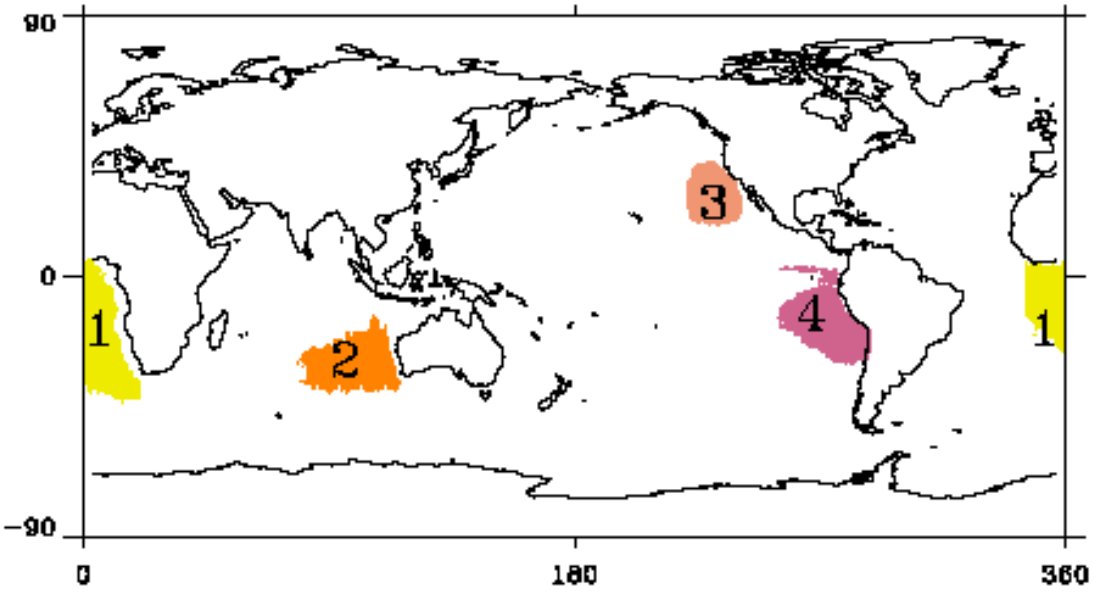


targeted regions

high clouds
>18%

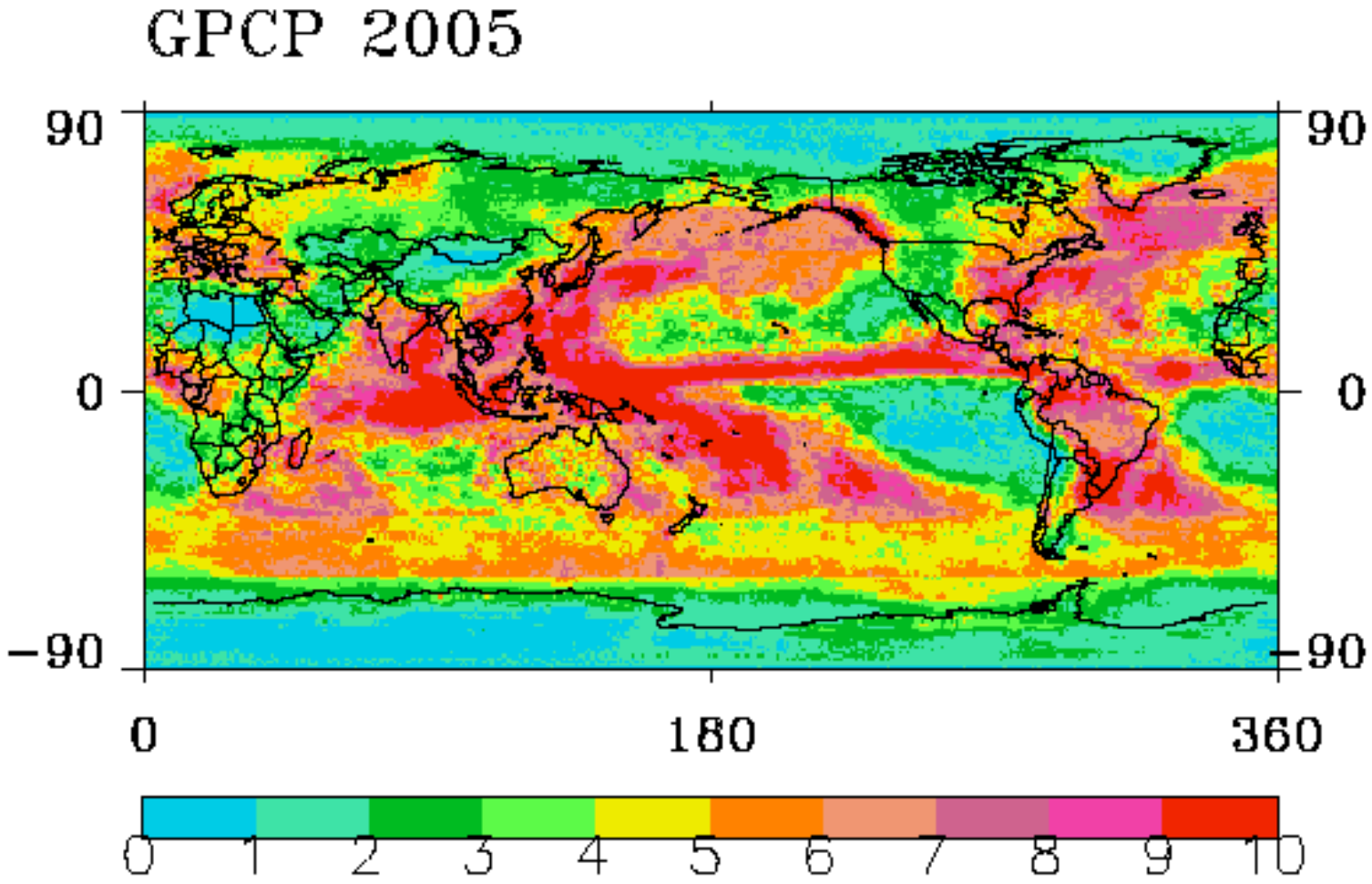


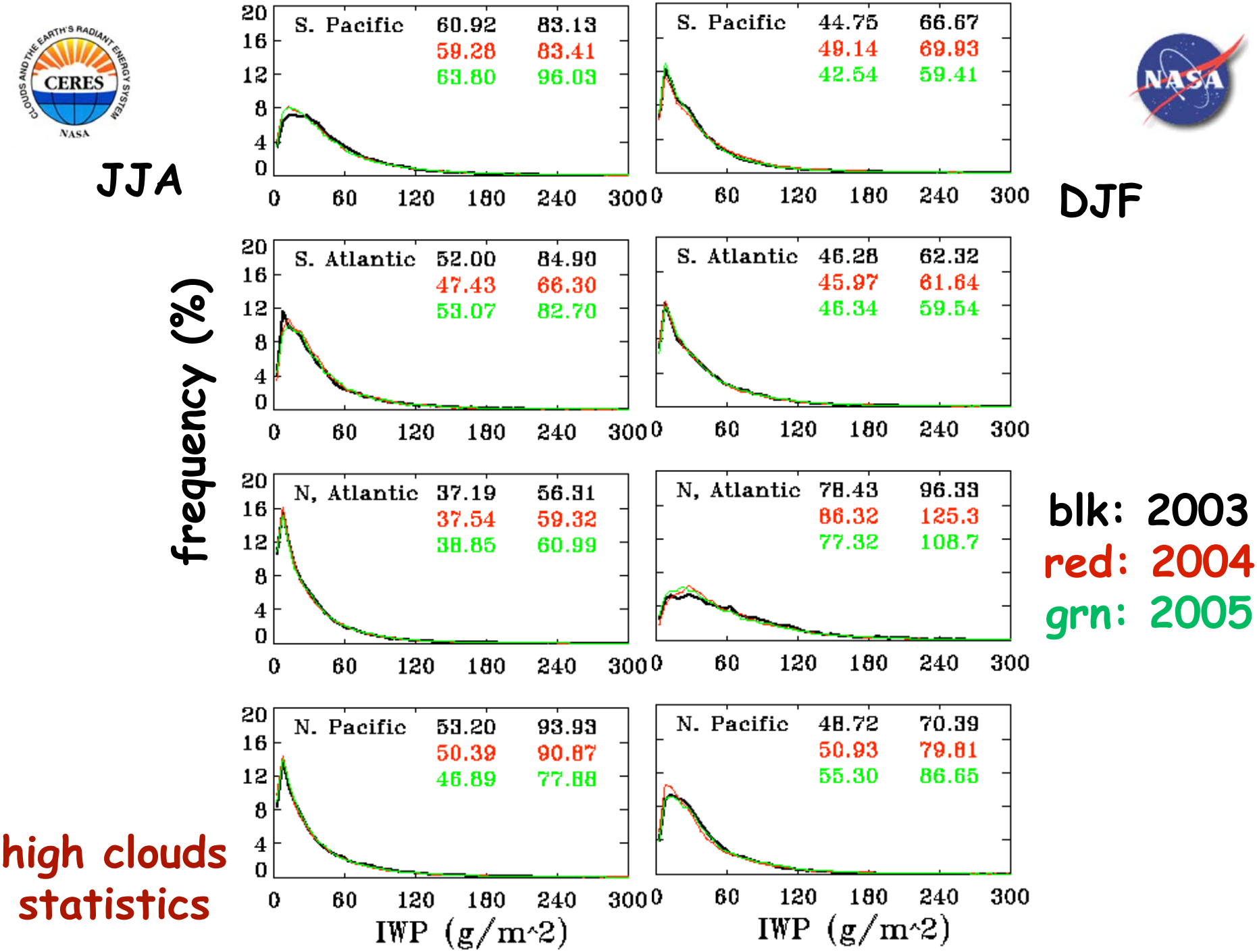
low clouds
>45%

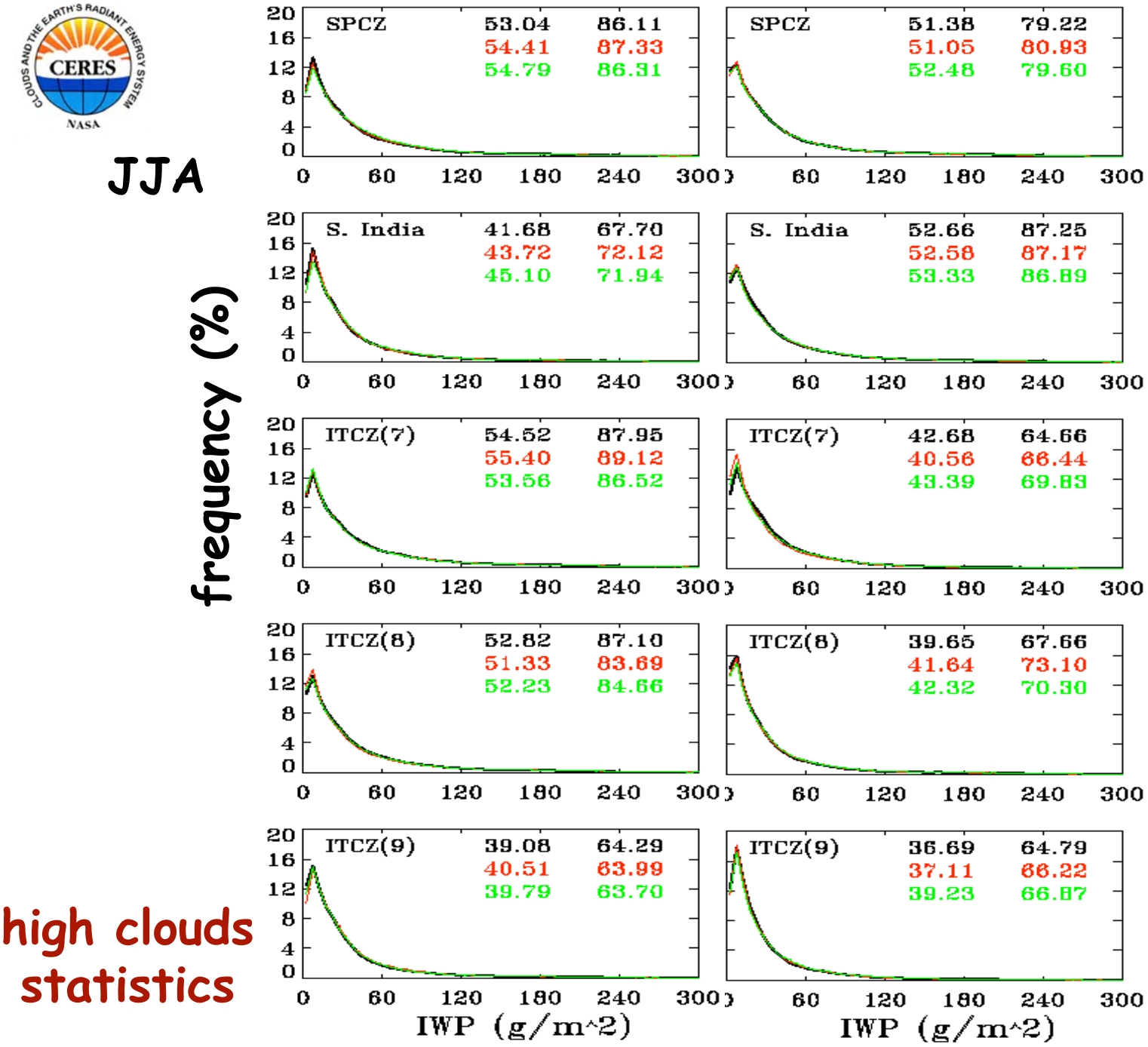


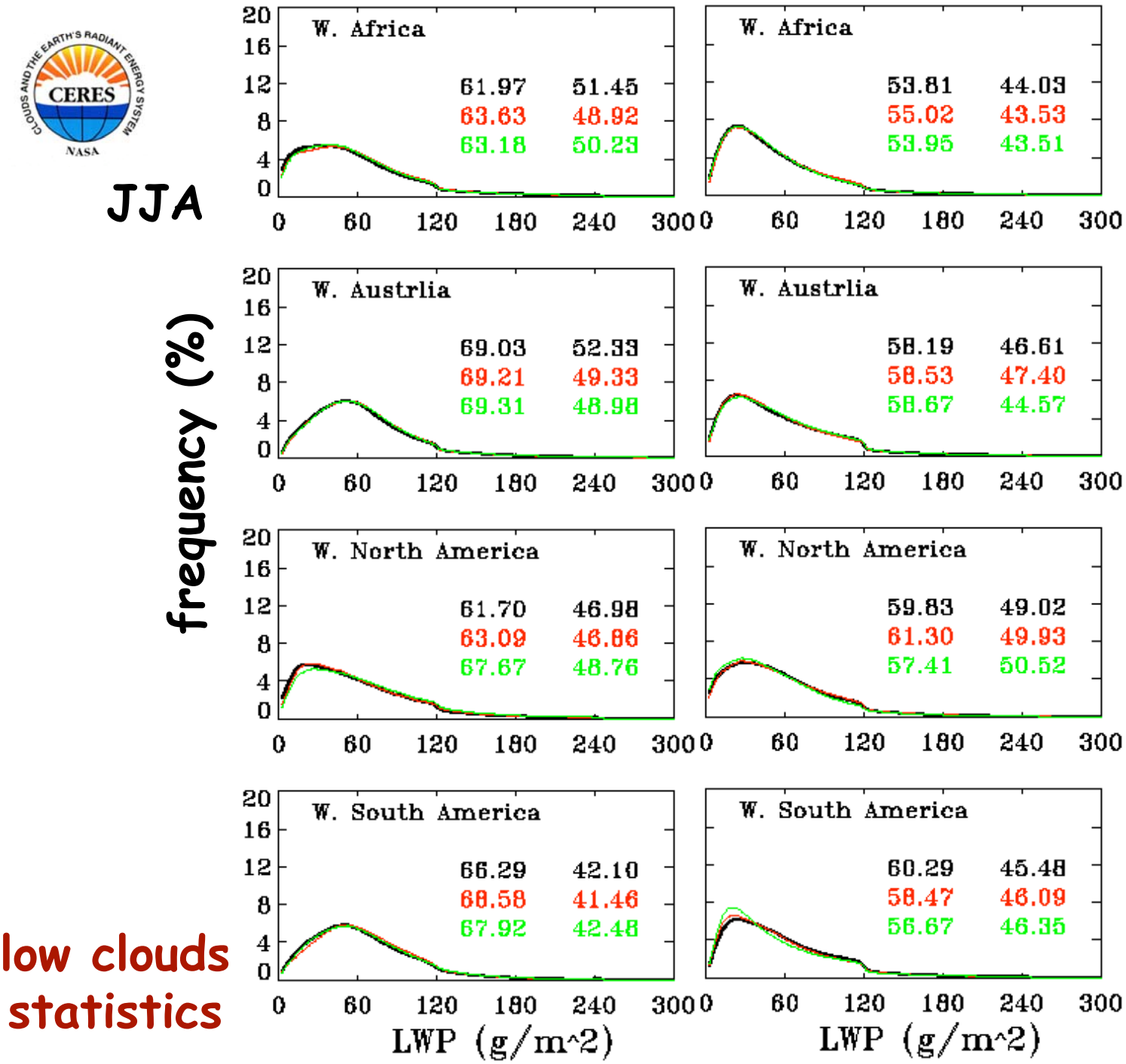
all clouds in the regions as long as in the type

Precipitation (mm/day)



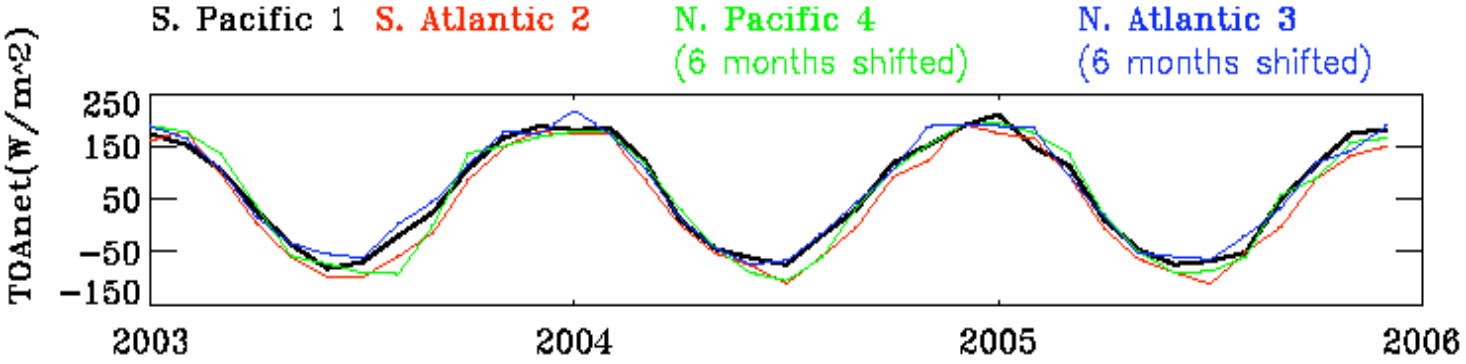

JJA
DJF
frequency (%)
S. Pacific 60.92 83.13
59.28 83.41
63.80 96.03
S. Pacific 44.75 66.67
49.14 69.93
42.54 59.41
S. Atlantic 52.00 84.90
47.43 66.30
53.07 82.70
S. Atlantic 46.28 62.32
45.97 61.64
46.34 59.54
N, Atlantic 37.19 56.31
37.54 59.32
38.85 60.99
N, Atlantic 78.43 96.33
86.32 125.3
77.32 108.7
N. Pacific 53.20 93.93
50.39 90.87
46.89 77.88
N. Pacific 48.72 70.39
50.93 79.81
55.30 86.65
0 4 8 12 16 20
0 60 120 180 240 300
IWP (g/m^2)
IWP (g/m^2)
blk: 2003
red: 2004
grn: 2005
high clouds statistics


JJA
DJF
frequency (%)
SPCZ 53.04 86.11
54.41 87.33
54.79 86.91
SPCZ 51.38 79.22
51.05 80.93
52.48 79.60
S. India 41.68 67.70
43.72 72.12
45.10 71.94
S. India 52.66 87.25
52.58 87.17
53.33 86.89
ITCZ(7) 54.52 87.95
55.40 89.12
53.56 86.52
ITCZ(7) 42.68 64.66
40.56 66.44
43.39 69.83
ITCZ(8) 52.82 87.10
51.33 83.69
52.23 84.66
ITCZ(8) 39.65 67.66
41.64 73.10
42.32 70.30
ITCZ(9) 39.08 64.29
40.51 63.99
39.79 63.70
ITCZ(9) 36.69 64.79
37.11 66.22
39.23 66.87
0 60 120 180 240 300
0 4 8 12 16 20
IWP (g/m^2)
IWP (g/m^2)
blk: 2003
red: 2004
grn: 2005
high clouds statistics

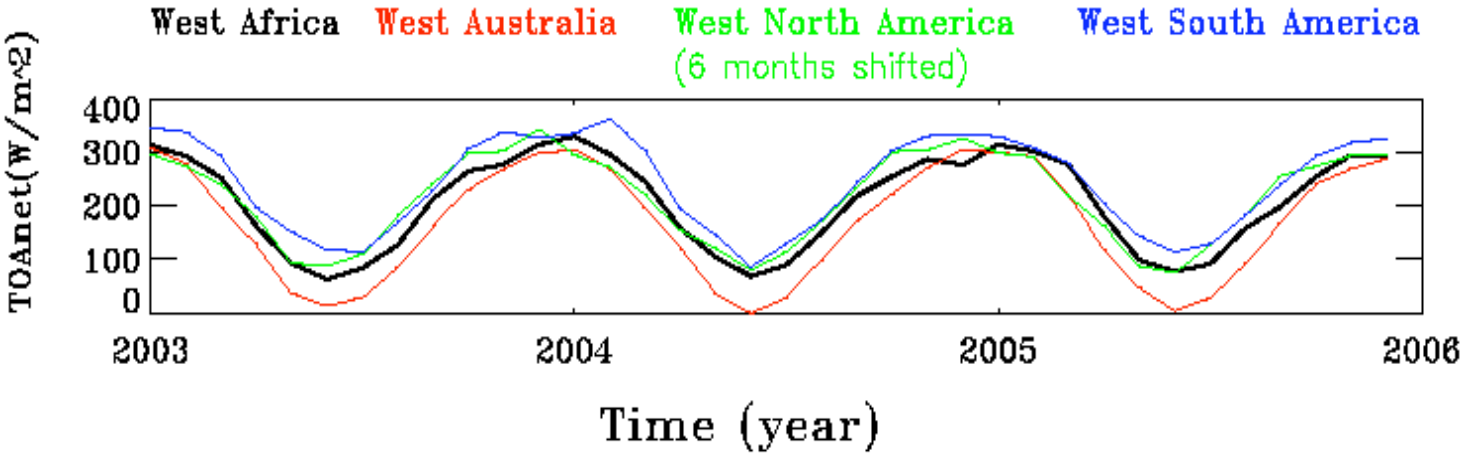

JJA
DJF
frequency (%)
W. Africa
61.97 51.45
63.63 48.92
63.18 50.23
W. Africa
53.81 44.03
55.02 43.53
53.95 43.51
W. Austrlia
69.03 52.33
69.21 49.33
69.31 48.98
W. Austrlia
58.19 46.61
58.53 47.40
58.67 44.57
W. North America
61.70 46.98
63.09 46.86
67.67 48.76
W. North America
59.83 49.02
61.30 49.93
57.41 50.52
W. South America
66.29 42.10
68.58 41.46
67.92 42.48
W. South America
60.29 45.48
58.47 46.09
56.67 46.35
0 60 120 180 240 300
0 4 8 12 16 20
LWP (g/m^2)
LWP (g/m^2)
blk: 2003
red: 2004
grn: 2005
low clouds statistics

TOA radiation (plotted by season)

high clouds

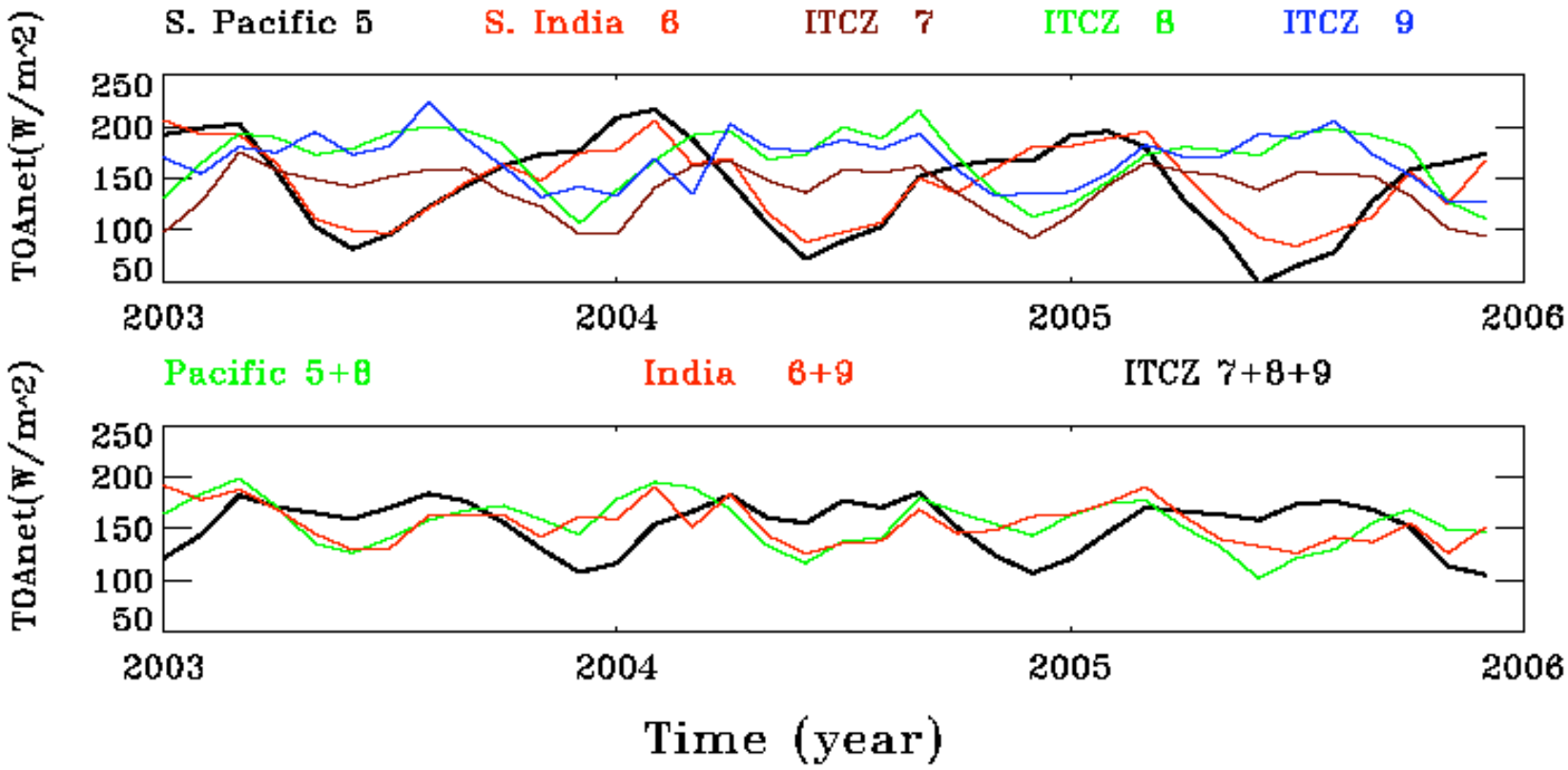


6-months-shifted data: N.P. & N.A.



low clouds

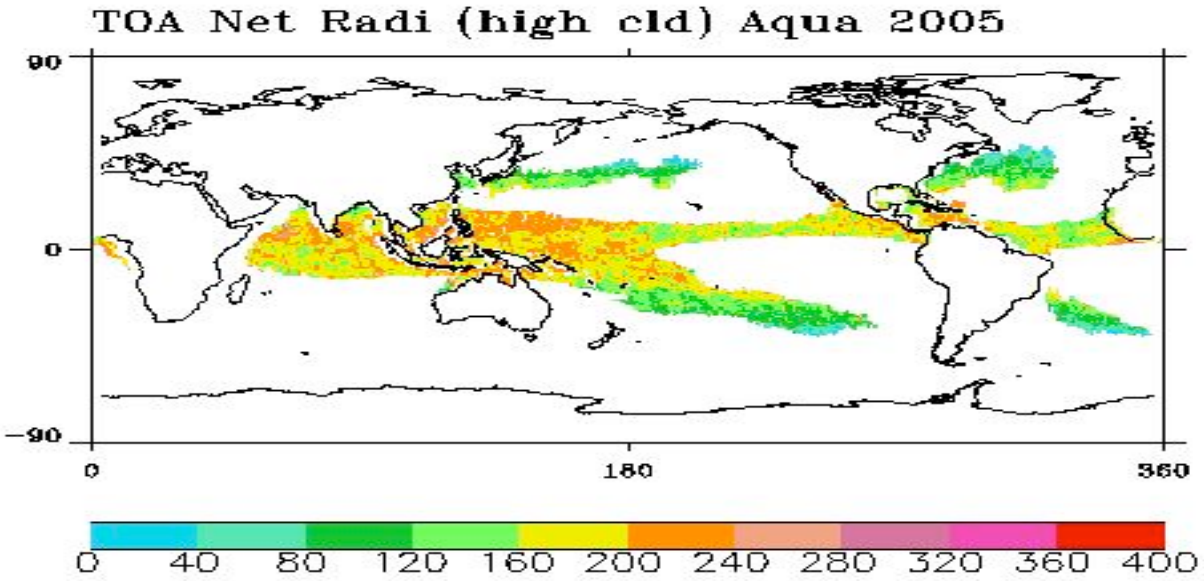
TOA radiation

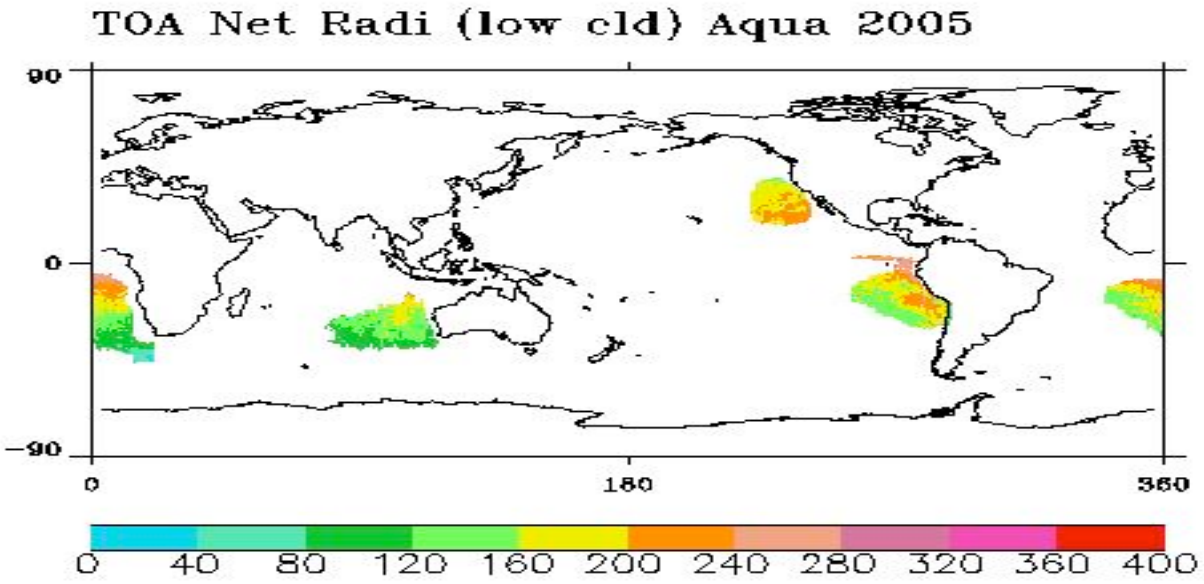


high similarity between western Pacific and India Ocean and among ITCZ areas

Annual mean TOA

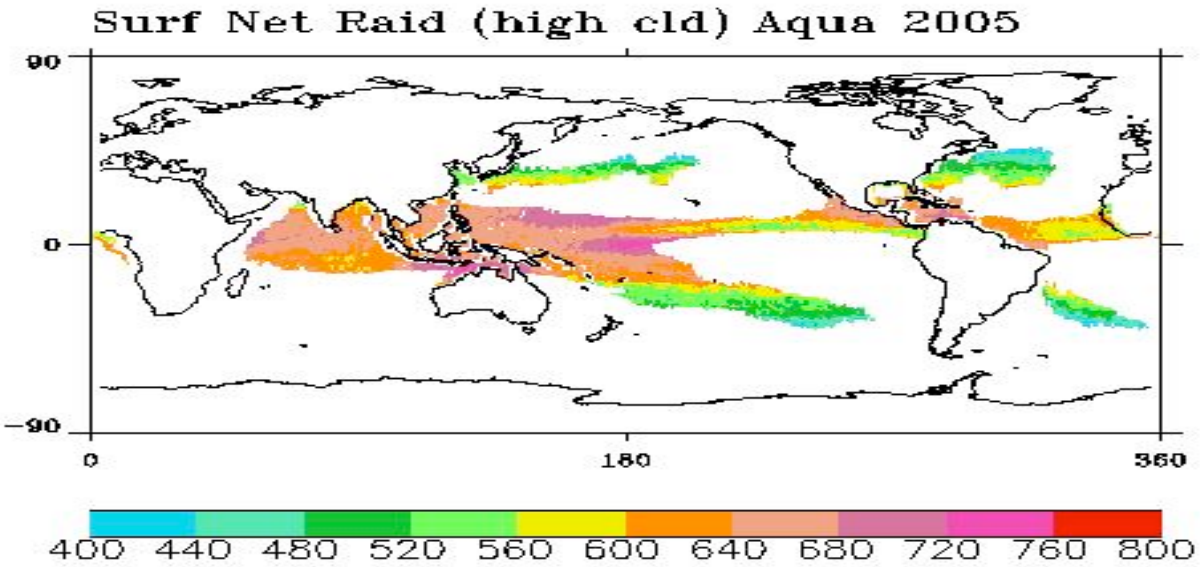
latitudinal gradient

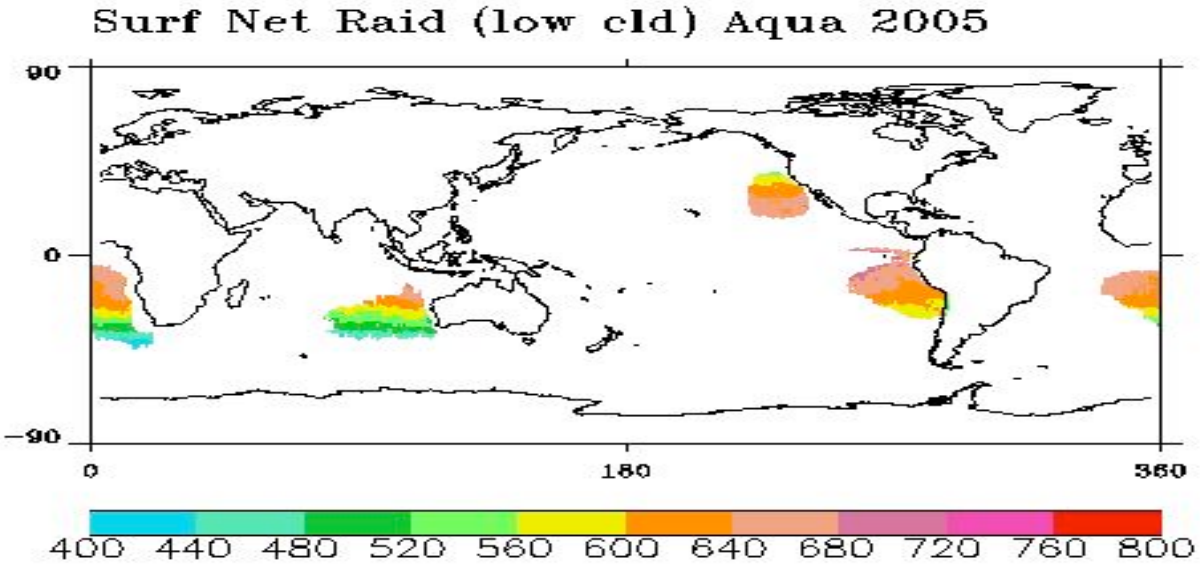




Annual mean SFC

very large sfc heating



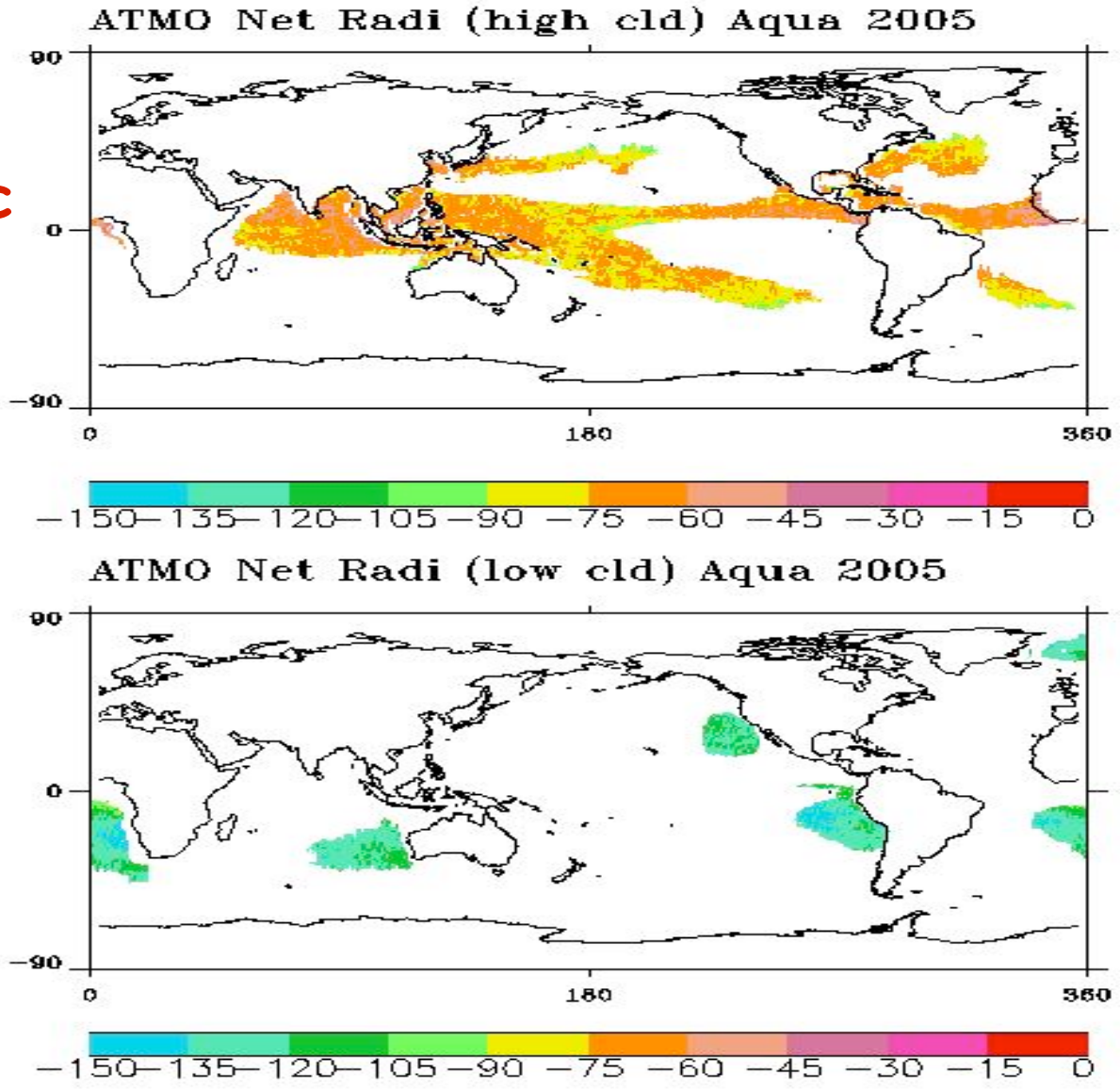


Annual mean atmos. heating

Atmospheric cooling

LW↓, LW↑ & weak SW

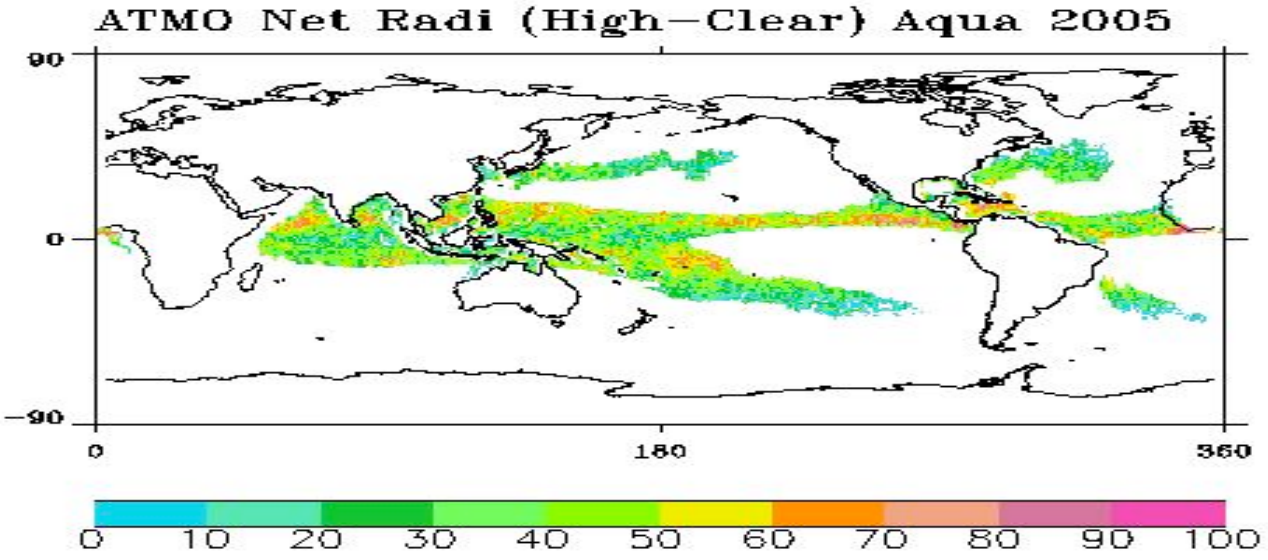
low cloud LW↑



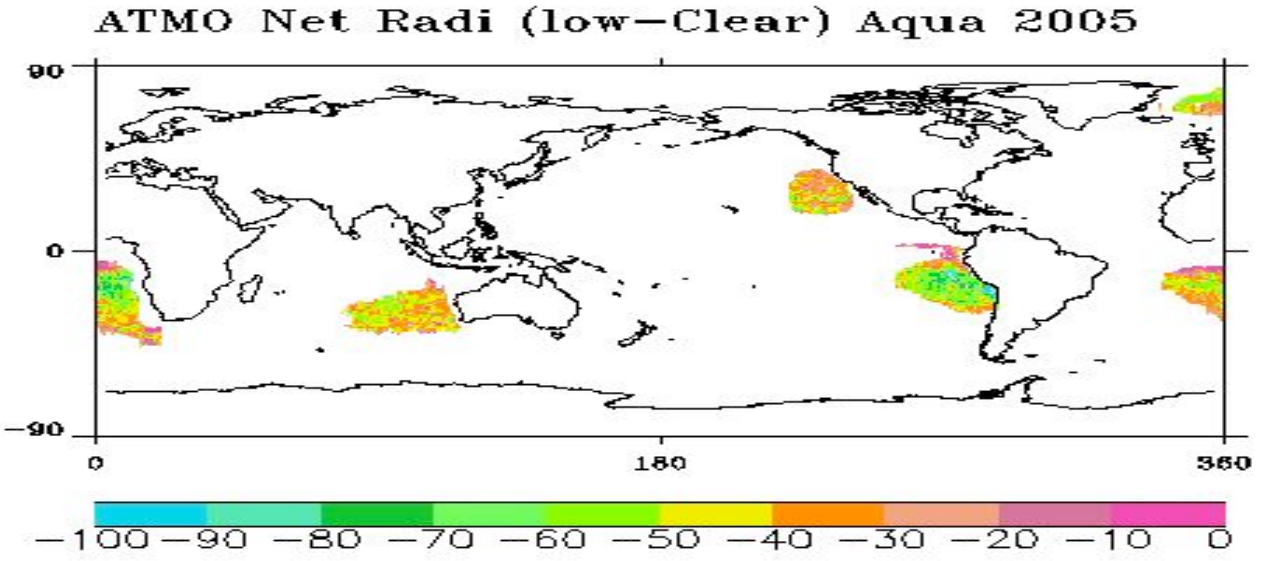
Atmos. radiative contrast

high cloud warming

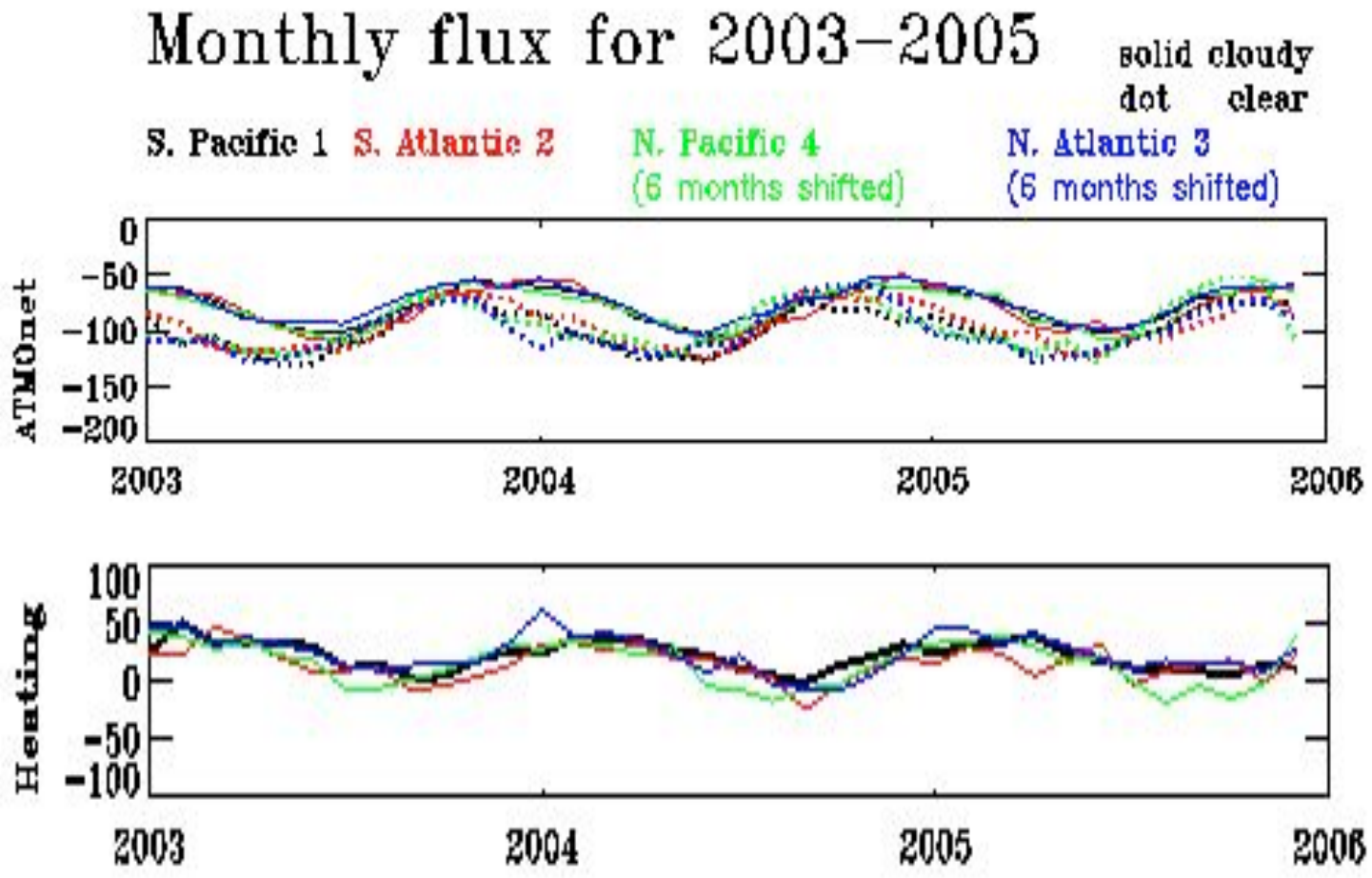
weak LW↑



low cloud similar LW↑ Strong LW↓



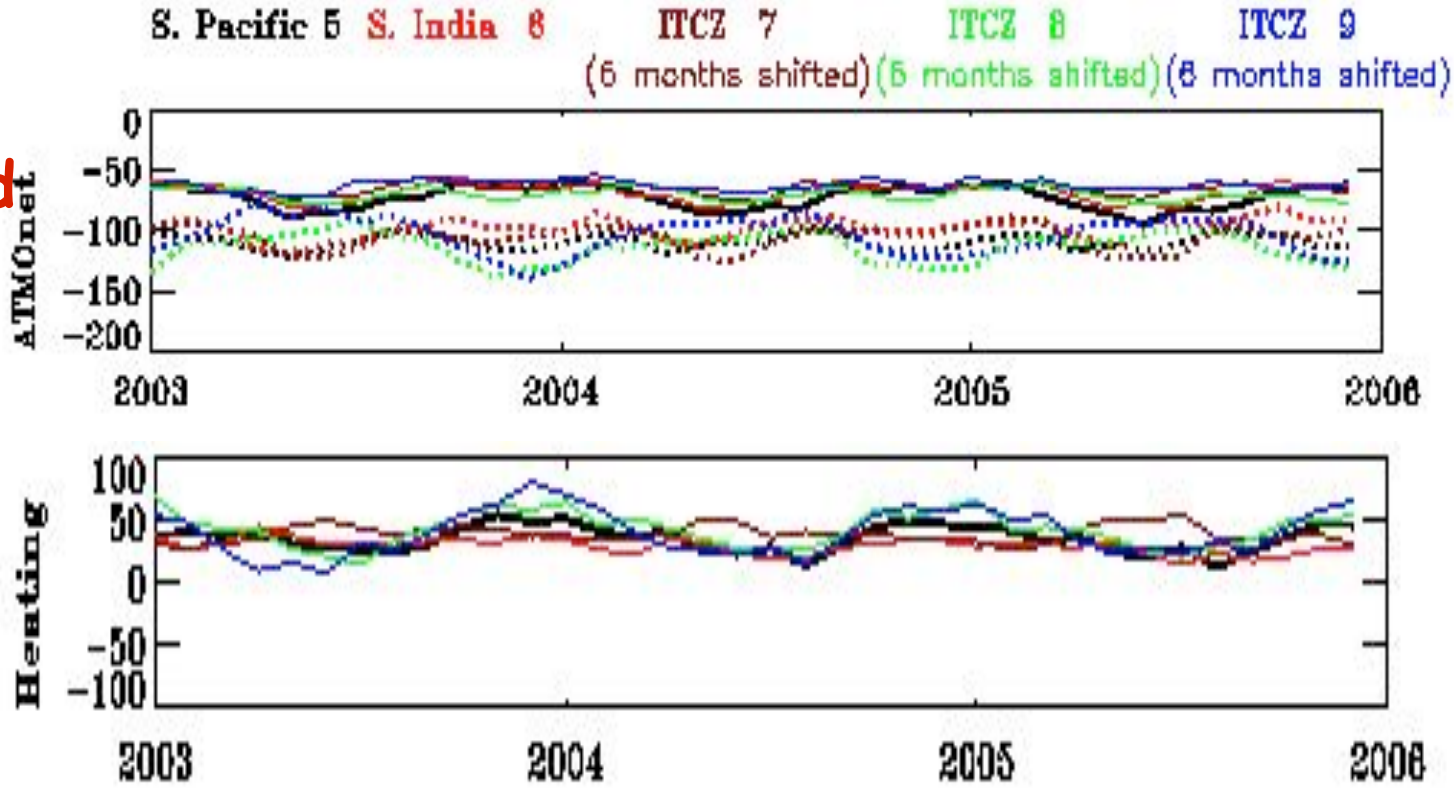
Midlatitude storm tracks



radiative heating within atmosphere:
tendency to reduce instability

tropical convergence zones

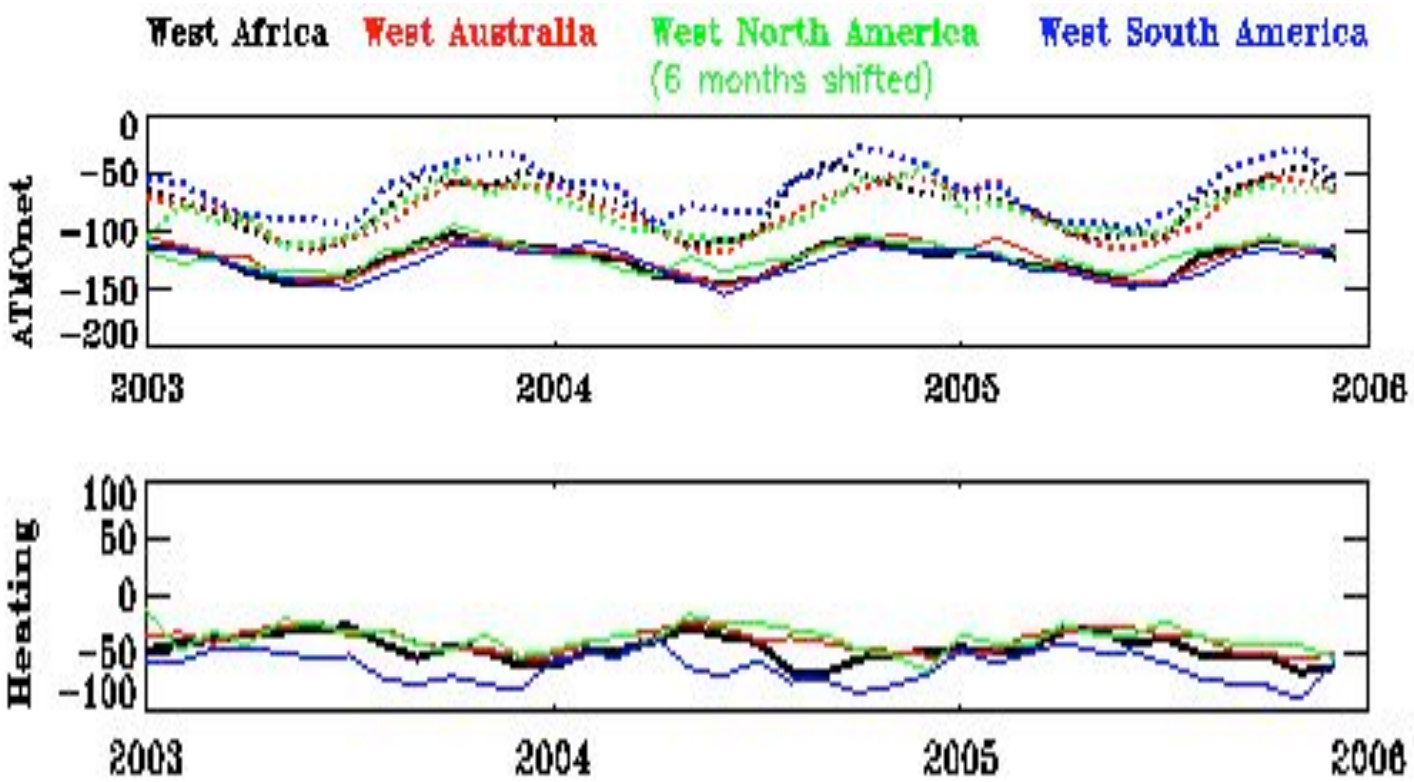
Clr: dot
Cld: solid



Similar story as those in storm tracks
except slightly stronger heating

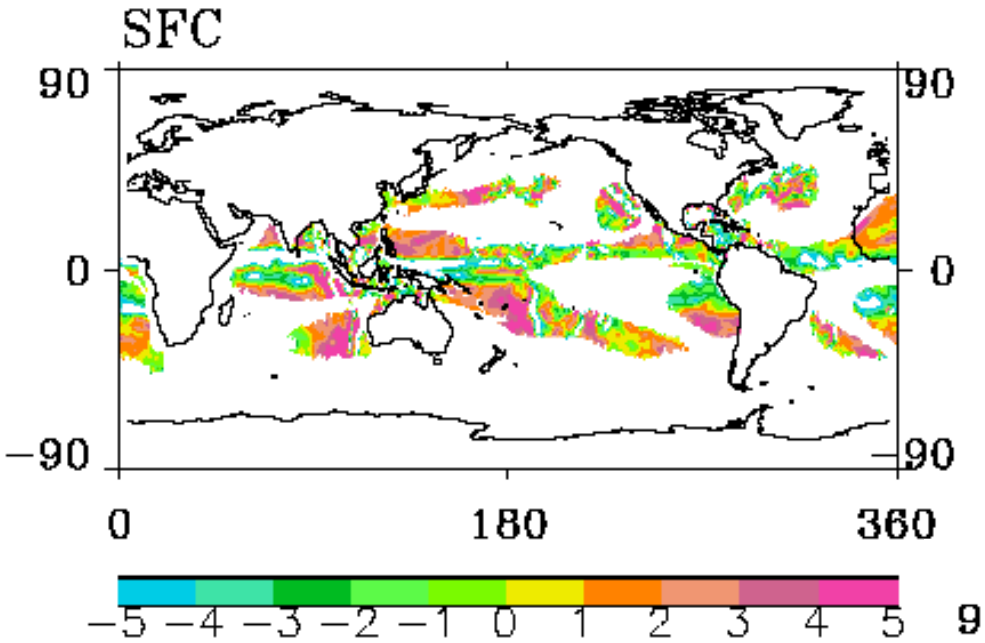
Low clouds

Clr: dot
Cld: solid



Radiative cooling at MBL cloud layer:
enhance subsidence and large-scale circulation

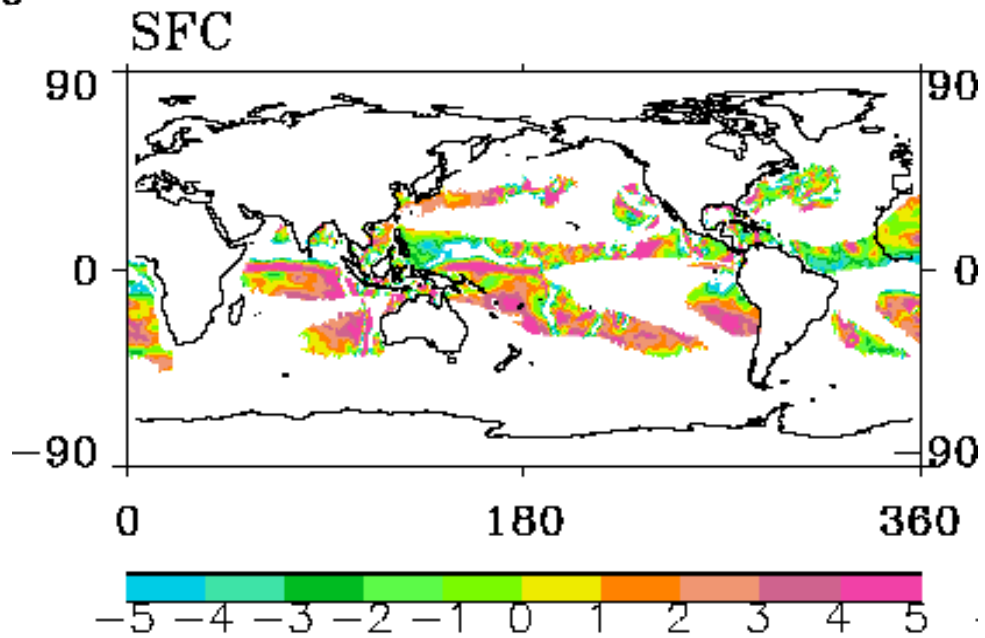
monthly mean div. (10^{-6}/s)



Jan. 2005

GEOS-4

some indications
for cloud formation



July 2005

Summary

- Year-to-year variations in LWP/IWP statistical distributions are very small for each season in a given selected area. The area-to-area change for the same types of clouds is also small.

- When the same types of clouds are analyzed in the same seasons, the differences in radiation fluxes of these clouds are remarkably similar.

- High high-cloud cover regions are also related to high precipitation as expect.

Summary

•The net atmospheric radiative fluxes under high clouds are positive compared to clear sky cases, which would increase atmospheric stability and reduce convection.

• The net atmospheric radiative fluxes under MBL clouds are negative compared to clear sky cases, which would increase atmospheric subsidence and enhance general atmospheric circulation in the tropics.

• Assimilated data may provide some indications for cloud formation. Models with higher spatial resolution & better cloud parameterization are needed, especially for MBL clouds. (Chicken and egg problem: better analysis needs better models, improved models needs advanced observations)

Acknowledgements

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